Modeling Adoption

2021 Potential and Goals

July 21, 2020
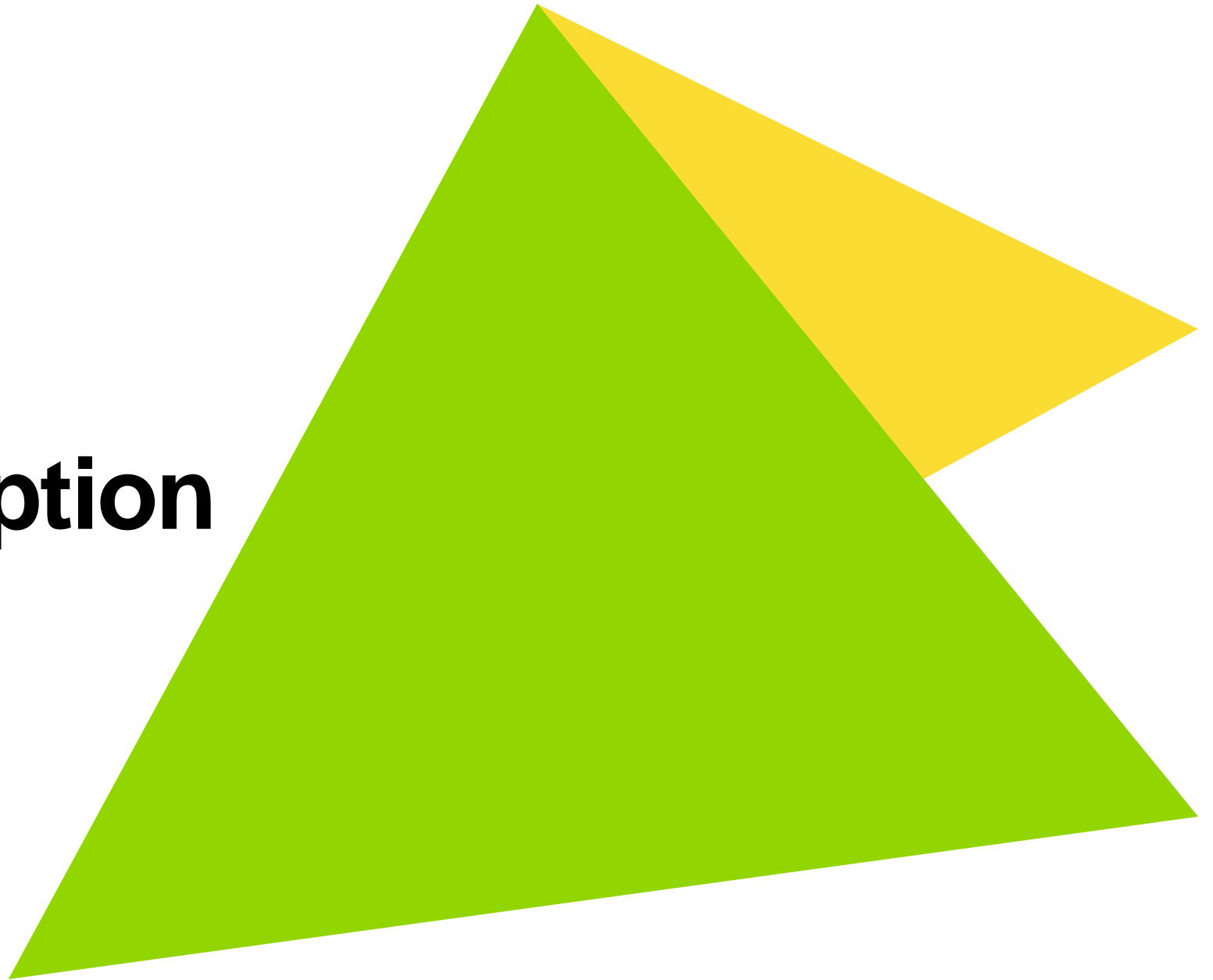
Agenda

01 | **Introduction**

02 | **Adoption Logic**

03 | **Leveraging Market Study Results**

04 | **Fuel Substitution***

05 | **EE-DR Integration**

06 | **Addressing COVID Impacts**

07 | **Closing**

*5 minute break

Conference Call Etiquette During Q&A Sessions

- We know everyone is working from home; don't feel bad about noise from kids, dogs, etc. if you are actively asking a question or making a comment

…BUT, after you speak please re-mute your microphone.

- Please do not place the line on hold
- We are actively monitoring the chat window; consider submitting questions/comments via chat

CPUC EE Potential & Goals Study Team

- **Coby Rudolph,** Project Lead
- **Genesis Tang**
- **Lisa Paulo**
- **Jessica Allison**
- **Peter Franzese**
- **Paula Gruendling,** Project Supervisor

Two EE Potential & Goals Tracks

1. Goals-adoption Policymaking Track (Policy Track):

Formal comments via EE rulemaking proceeding. Topics have included:

- Energy efficiency portfolio objectives
- Energy efficiency Goals
- Energy efficiency / IRP Integration Opportunities
- Portfolio assessment of cost-effectiveness and budget approval
- Prioritization & other issues

2. Potential and Goals Study Track (Study Track):

Informal work on the EE Potential & Goals Study.

- CPUC Energy Division staff (along with Guidehouse) is soliciting ongoing, informal feedback from stakeholders on methodological and technical issues related to the Study.
- As in previous studies, stakeholder engagement on technical will take place in coordination with the CEC's Demand Analysis Working Group (DAWG).

EE Potential & Goals Background

Potential and Goals Study serves multiple purposes:

1. PG Study informs the CPUC Decision adopting IOU Energy Efficiency Goals

2. EE Goals inform the statewide Demand Forecast (& IRP), SB 350 forecast.

Potential & Goals Next steps (Subject to Change)

Activity	Track / Venue	When
ALJ Kao Ruling Questions (from 3/12/20)	Policy / formal comment	Comments submitted, Replies by 6/5
Study launch Workshop & Workplan	Study / informal comment	April 2020
Measure characterization, data inputs	Study / informal comment	June 2020
Modeling	Study / informal comment	Today
Scenarios, Top-down scoping, Low income modeling	Study / informal comment	Q4 2020
EE/DR/IRP Integration, Locational post-processing, Draft results	Study / informal comment	Q1 2021
Proposed Decision on Goals Adoption for 2022 and Beyond	Policy / formal comment	Q2 /Q3 2021
Decision on Goals Adoption for 2022 & Beyond	Policy / formal comment	Q3 2021
Additional Policy Activities TBD	Policy / formal comment	TBD

Complete / Nearly complete

Speakers Today

Amul Sathe
Project Director
Guidehouse

Tyler Capps
Modeling Team Lead
Guidehouse

Julie Penning
EE Modeling Lead
Guidehouse

Vania Fong
Modeling Support
Guidehouse

Brian Gerke
DR Modeling Lead
LBNL

PG Study Workflow
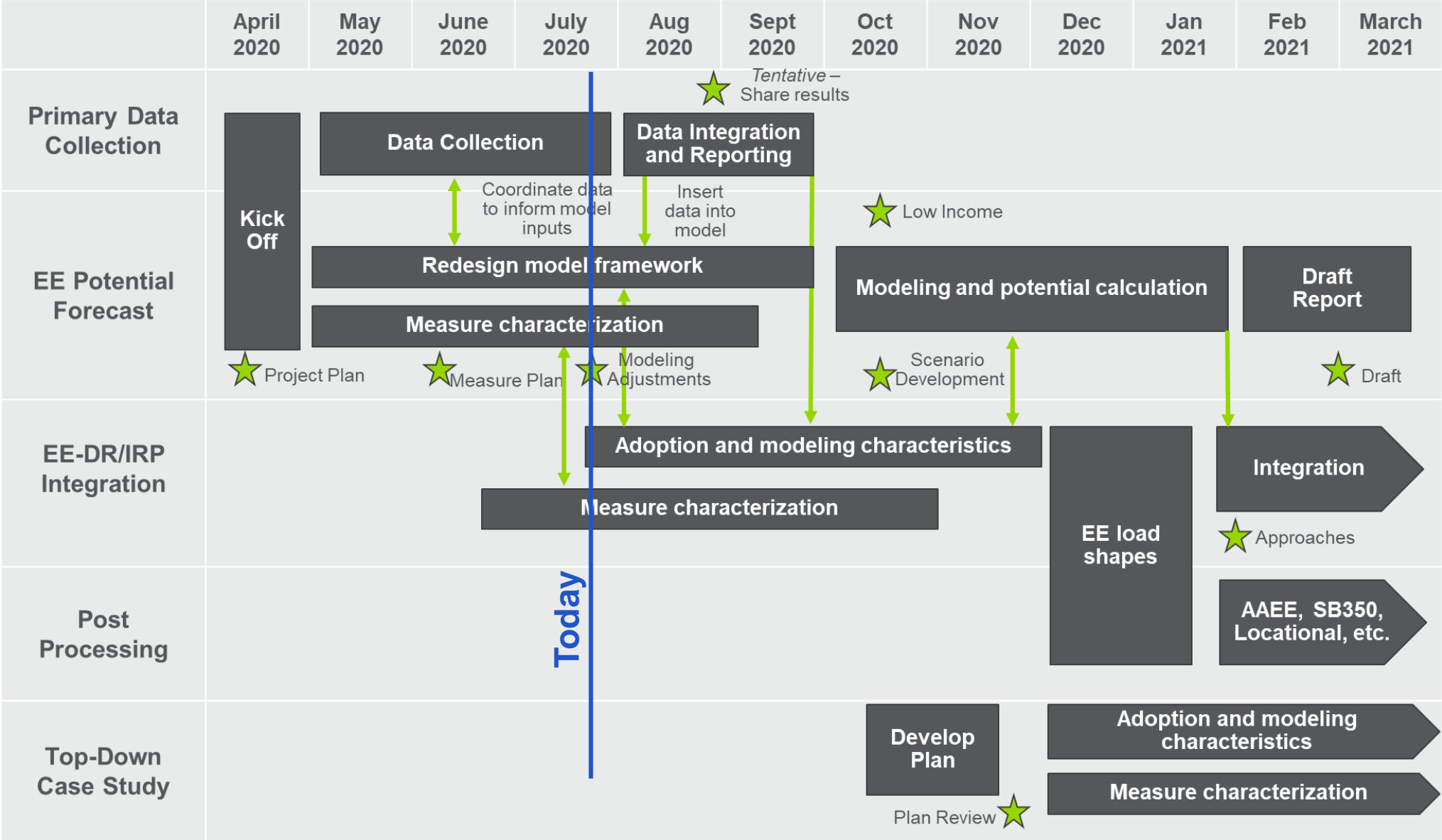
Objectives for today

PG study approach for modeling adoption

Adoption Logic

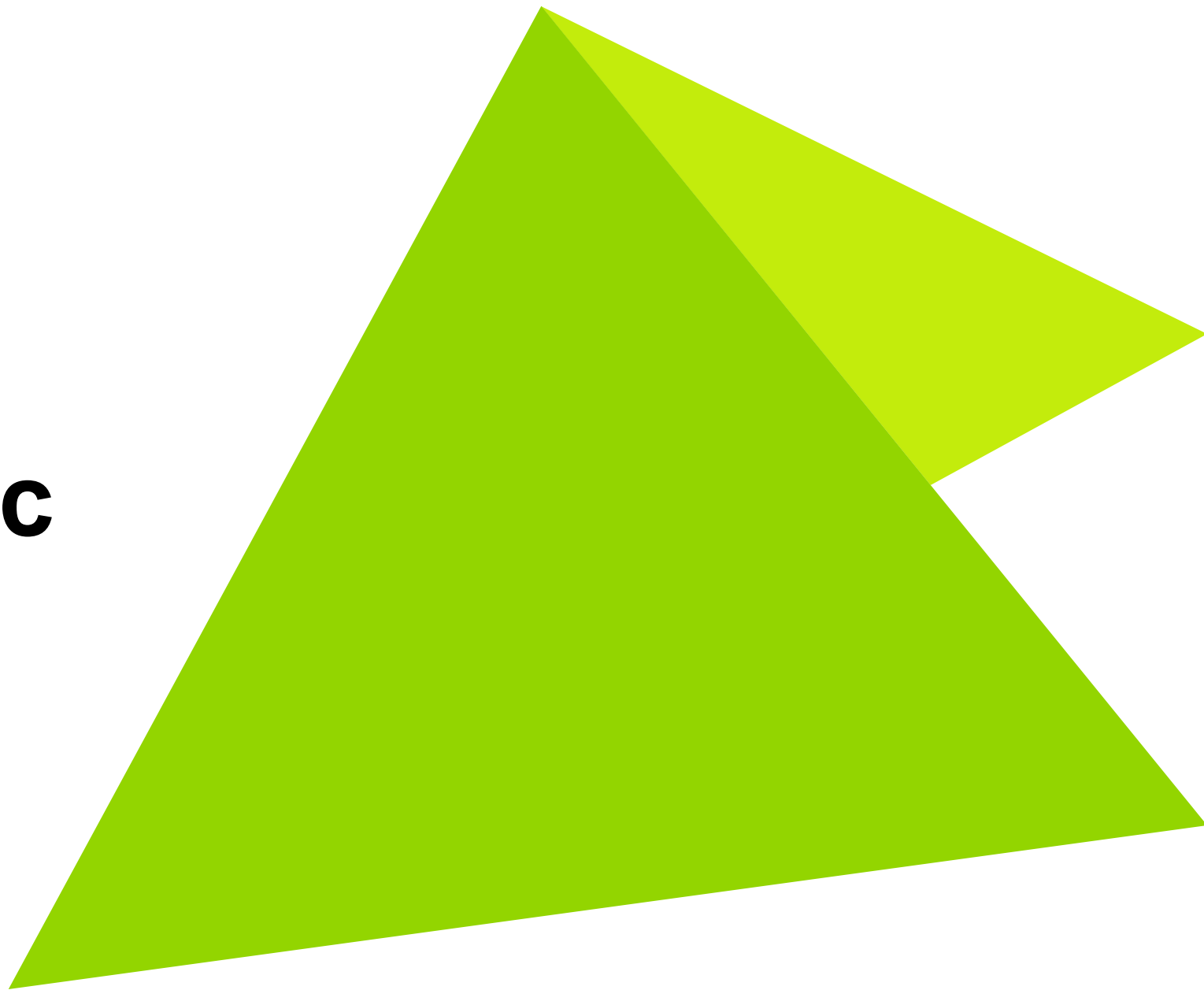Mapping of market study responses to model inputs

Introduction of EE-DR co-benefits

Introduction of fuel substitution logic

COVID-19 impacts

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Adoption Logic

Stakeholder Presentation
Tyler Capps, Guidehouse

Introduction

- **Discussion topics:**
  - High level review of the 2019 PG study adoption logic
  - Changes to the adoption logic for the 2021 study

What is a Potential Study?

Technical Potential
Total energy savings available by end-use and sector, relevant to current population forecast

Avoided Costs
Measure Costs →

Economic Potential
CPUC Cost-effectiveness Screen

Program Intervention
Customer Adoption Characteristics →

Achievable Potential
EE expected to be adopted by programs

↓

Establishes Goals & Scenarios for Forecast

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2019 Study - Market Adoption Overview

Annual population making a purchase decision for a given technology

Adoption Logic

Measure Awareness	→	Measure Willingness	→	Measure Adoption

- Customers have to be aware before they can consider adoption
- Bass diffusion model defines how awareness grows over time

- Based on **financial attractiveness** of the measure, how many people would adopt it?
- Decision model forecasts what fraction of the population will choose what product (baseline vs. efficient)

- Apply awareness and willingness to factors to the population making the decision
- Result is: number of annual adopters of each technology (base vs. efficient)

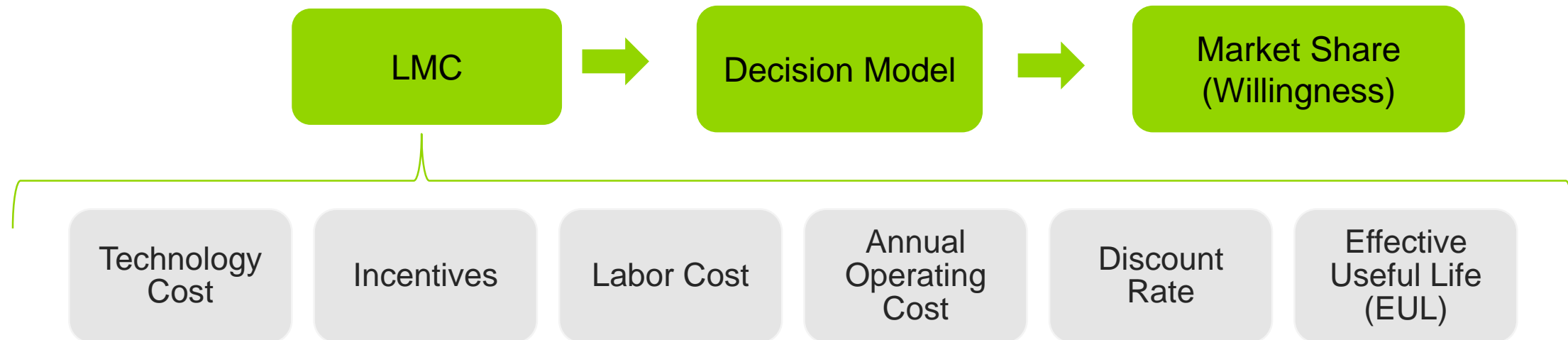Calculate savings, costs, and benefits based on forecasted adoption

2019 Study – Measure Willingness – Res/Com
Calculate market share within technology groups

**Residential and Commercial Technologies used a <u>Single Attribute Decision Model</u>**

- The single attribute is "financial attractiveness"

- Financial attractiveness is quantified as net present value of lifetime measure costs (LMC)

- Model compared the LMC of competing technologies

LMC → Decision Model → Market Share (Willingness)

Technology Cost	Incentives	Labor Cost	Annual Operating Cost	Discount Rate	Effective Useful Life (EUL)

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2019 Study – Measure Willingness – Res/Com
Calculate market share within technology groups

LMC ratios between efficient and base technologies determine market share

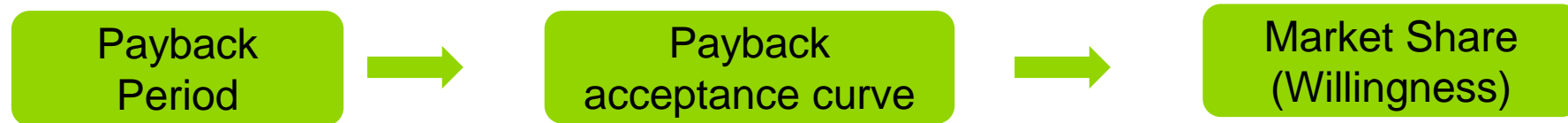LMCs for all measures are equal

LMCs are highly varied
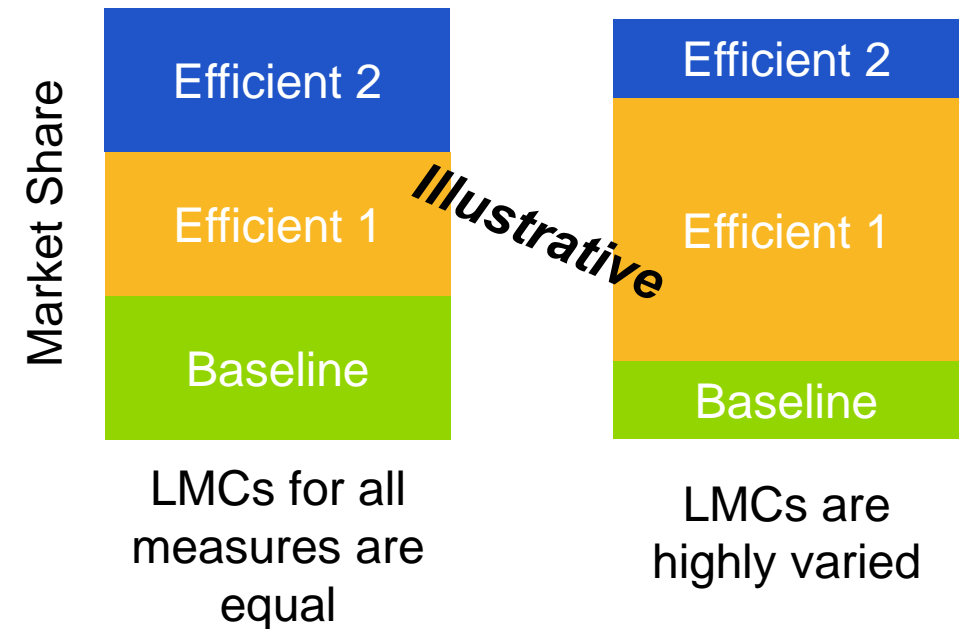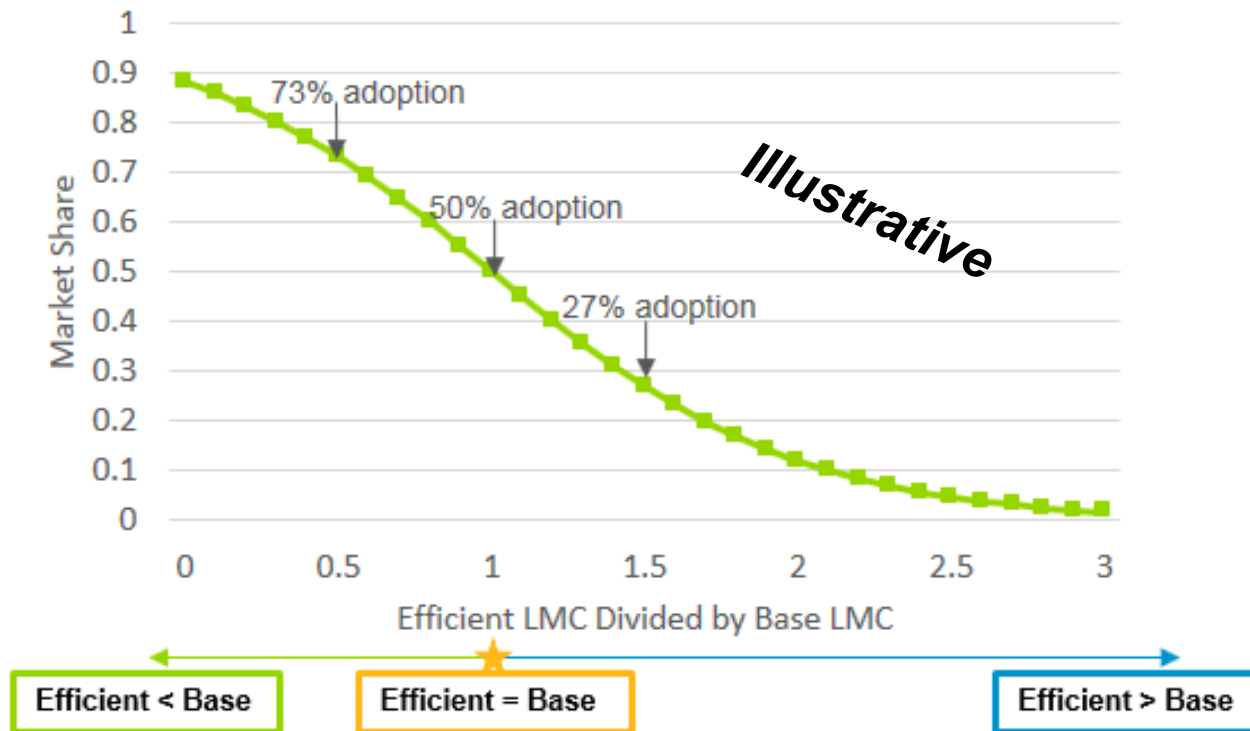
2019 Study – Measure Willingness – Ind/Ag
Calculate market share within technology groups

Industrial and Agricultural sectors used a <u>Payback Acceptance Curve</u>

- Used when information on baseline technology costs are not available

Payback Period	→	Payback acceptance curve	→	Market Share (Willingness)
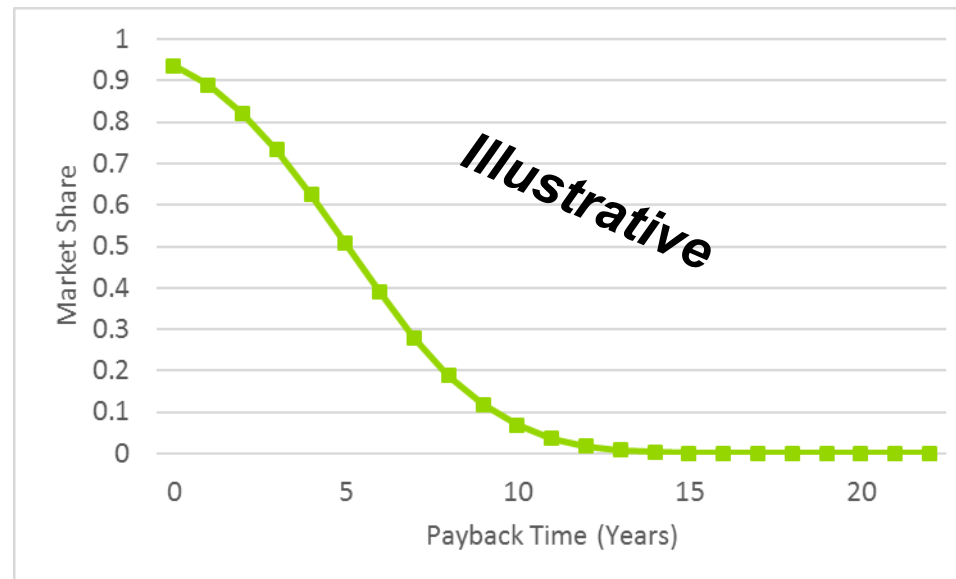
Impetus for Updating Logic

- Stakeholder feedback from *Approaches for Assessing Energy Efficiency Potential & Goals Workshop* (October 2019)
  - Economics is not the only driver of adoption behavior, and in some cases, it may not even be the primary driver
  - Suggestions to study customer behavior and preferences

- Research outlines the importance of social and behavioral insights in modeling adoption of EE
  - Understanding of non-rational decision making
  - Other program features impact adoption beyond financial incentives

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2021 Study - Update to Willingness Calculation – Res/Com

Updating the Decision Model to include <u>Multiple Attributes</u>

- Accounts for factors beyond LMC in adoption decisions

- Will be informed by primary data collection from the parallel market studies

Lifetime Cost (LMC)	Upfront Cost	Hassle Factor
Eco Impacts	Eco Signaling	Non-conservation Performance

→ Decision Model → Market Share (Willingness)
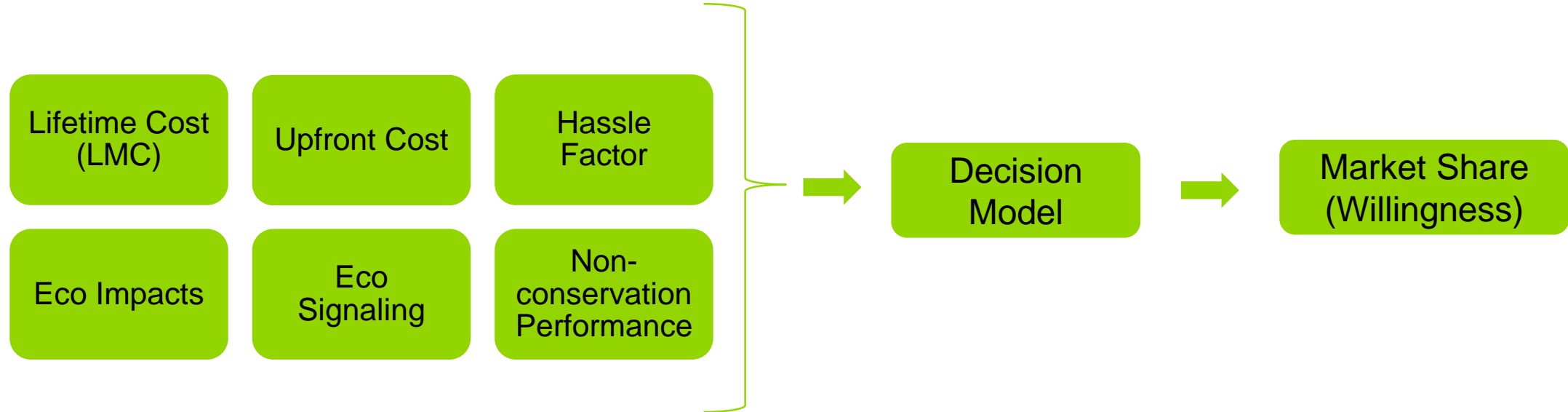
- Industrial/Agriculture modifications are still under development

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Questions

- What clarifying questions do you have?

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Leveraging Market Study Results

Stakeholder Presentation
Vania Fong, Guidehouse

Introduction

- Discussion topics:
  - Refresher on scope
  - How we intend to use the primary data collected to inform the model's decision algorithms

- Key questions for stakeholders:
  - *What considerations could be accounted for when basing model logic on survey responses?*

Summary

Objective

Consider a broader set of customer preferences on economic and noneconomic factors when modeling technology adoption

Data Source

Collect residential and commercial customer preference data via a market adoption study

Approach

Translate survey responses to customer preference weights and apply weights to technology characteristics to determine market share

Outcome

PG Study results that better reflect real-world adoption behavior

Data Source
Market Adoption Study

Study Objective

- Collect customer characteristics, attitudes and behaviors to inform adoption decision-making factors. Topics covered:
  - EE program awareness
  - Motivations and attitudes
  - Technology adoption decisions and scenarios
  - DR Participation
  - Demographics/Firmographics
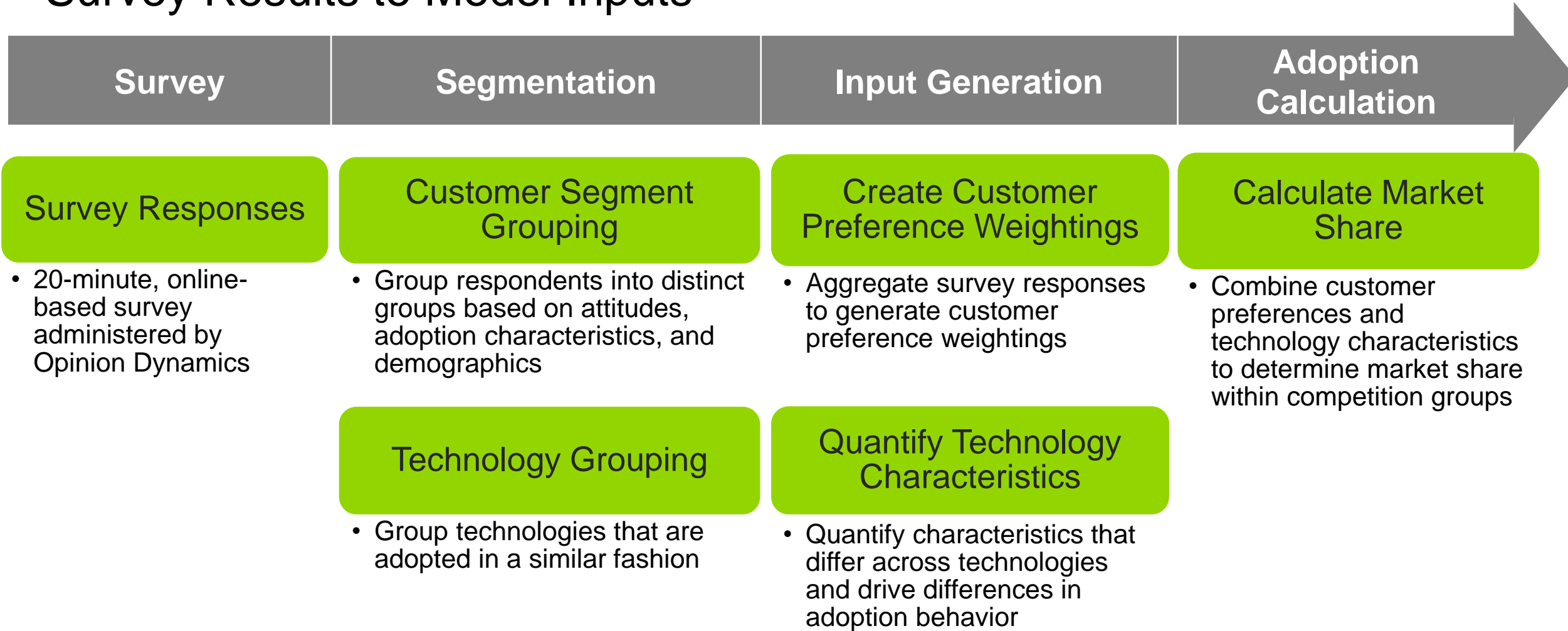 - COVID-19 Impacts

Methodology

- Primary Research
  - 20-minute online survey
- Secondary Research
  - Relevant reports, evaluations, and data sources

Segment	Sample Size
Residential Single Family	600
Residential Multifamily (Building Owners)	100
Small Commercial	400
Large Commercial	200

Logic Flow
Survey Results to Model Inputs

Survey	Segmentation	Input Generation	Adoption Calculation

Survey Responses

- 20-minute, online-based survey administered by Opinion Dynamics

Customer Segment Grouping

- Group respondents into distinct groups based on attitudes, adoption characteristics, and demographics

Technology Grouping

- Group technologies that are adopted in a similar fashion

Create Customer Preference Weightings

- Aggregate survey responses to generate customer preference weightings

Quantify Technology Characteristics

- Quantify characteristics that differ across technologies and drive differences in adoption behavior

Calculate Market Share

- Combine customer preferences and technology characteristics to determine market share within competition groups

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Segmentation

Customer Subsegment Grouping

- Select features for differentiation
- Group customers with similar attitudes and adoption characteristics
- Identify distinct traits for each subsegment
  - Possible groups include "Eco-Friendly", "Frugal", "High-Tech Oriented"

Technology Grouping

- Group technologies that are adopted in a similar manner, using pre-identified technology groupings as a starting point

Input Generation

Quantify Technology Characteristics

- Use measure characterization data and technology expertise to calculate a numerical or binary value for each characteristic

Create Customer Preference Weighting

- Characterize relative weightings (0-100%) that indicate the importance of each technology characteristic in determining adoption

- Values can be interpreted as percentage of decision driven by each technology characteristic
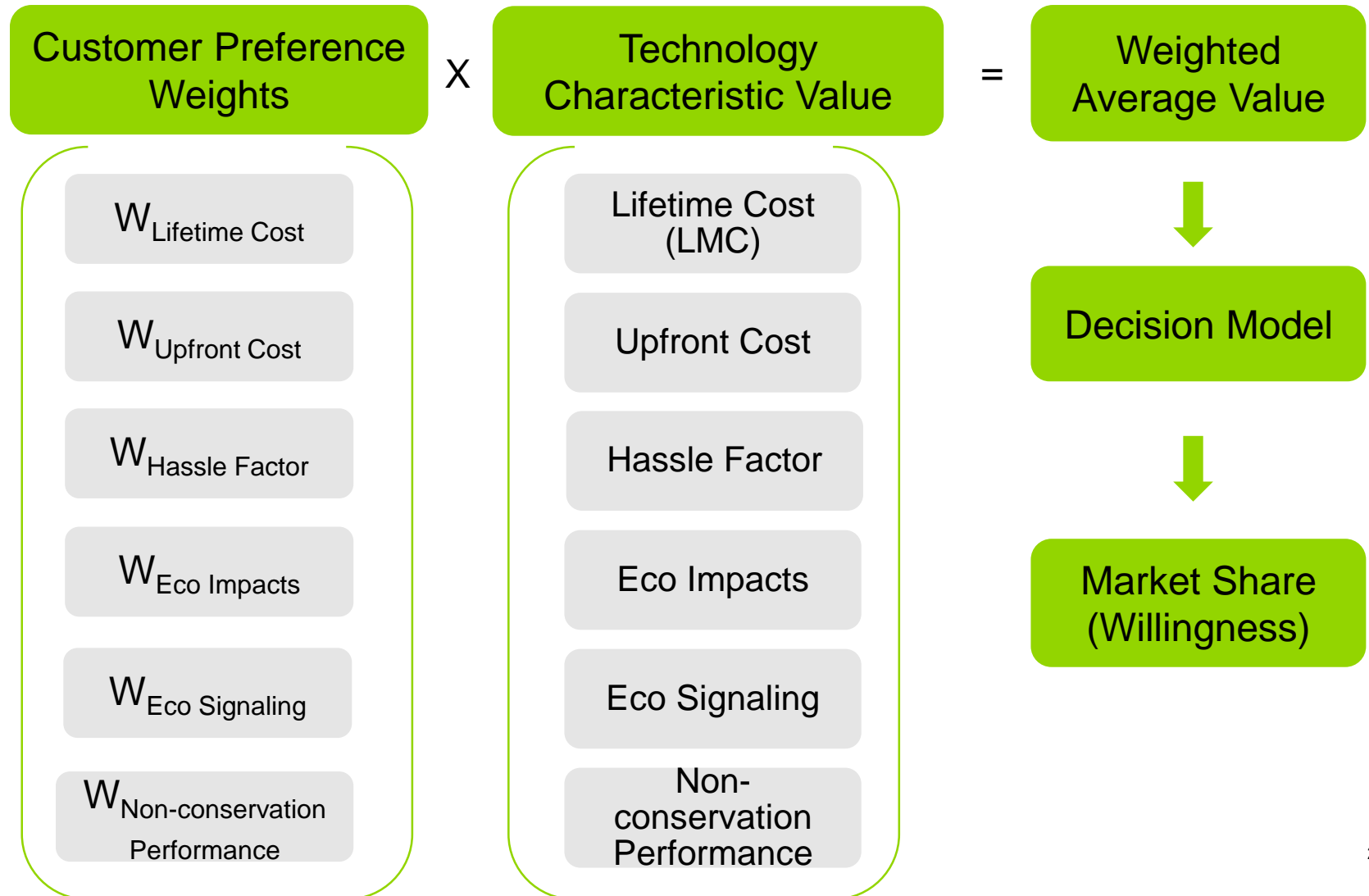
Technology Attributes	Customer Preference Weighting	
	Customer Group #1	**Customer Group #2**
Lifetime Cost (LMC)	5%	30%
Upfront Cost	5%	30%
Hassle Factor	5%	25%
Eco Impacts	50%	5%
Eco Signaling	30%	5%
Non Conservation Performance	5%	5%

Illustrative

Adoption Calculation

- Use customer preference weights to calculate weighted average of relative technology characteristics for every measure

- Feed weighted value into decision model to calculate market share

Customer Preference Weights

$W_{\text{Lifetime Cost}}$

$W_{\text{Upfront Cost}}$

$W_{\text{Hassle Factor}}$

$W_{\text{Eco Impacts}}$

$W_{\text{Eco Signaling}}$

$W_{\text{Non-conservation Performance}}$

X

Technology Characteristic Value

Lifetime Cost (LMC)

Upfront Cost

Hassle Factor

Eco Impacts

Eco Signaling

Non-conservation Performance

=

Weighted Average Value

↓

Decision Model

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Market Share (Willingness)

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Questions

- What considerations could be accounted for when basing model logic on survey responses?

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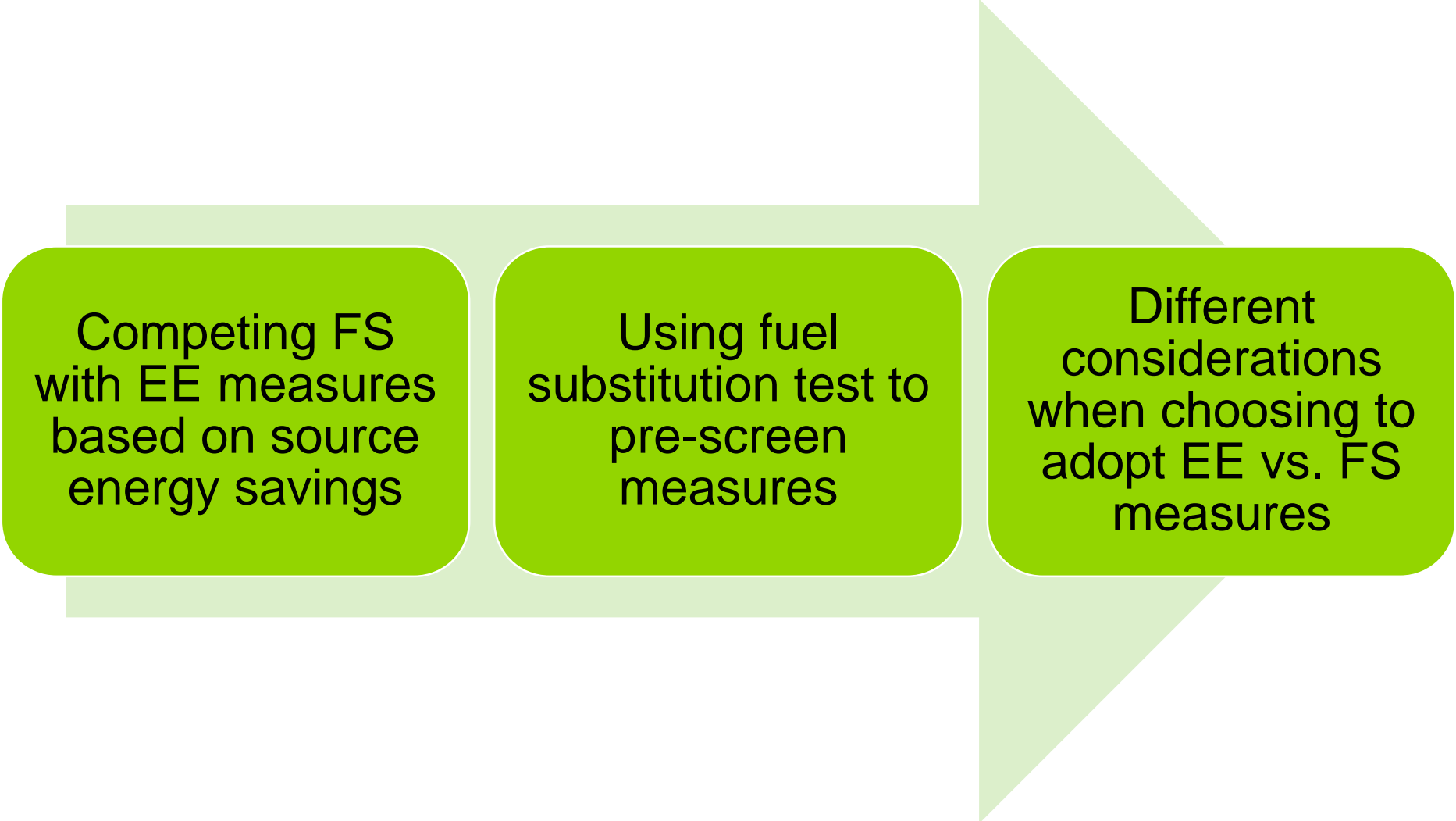# Fuel Substitution (FS)

Stakeholder Presentation
Tyler Capps, Guidehouse

Introduction

- **Discussion topics:**
  - Fuel substitution logic for technical, economic, and market potential
  - Fuel substitution competing with energy efficiency

- **Key questions for stakeholders:**
  - How do we handle incentive layering and (potentially) savings attribution?

Three Areas of Unique Fuel Substitution Logic

Competing FS with EE measures based on source energy savings

Using fuel substitution test to pre-screen measures

Different considerations when choosing to adopt EE vs. FS measures
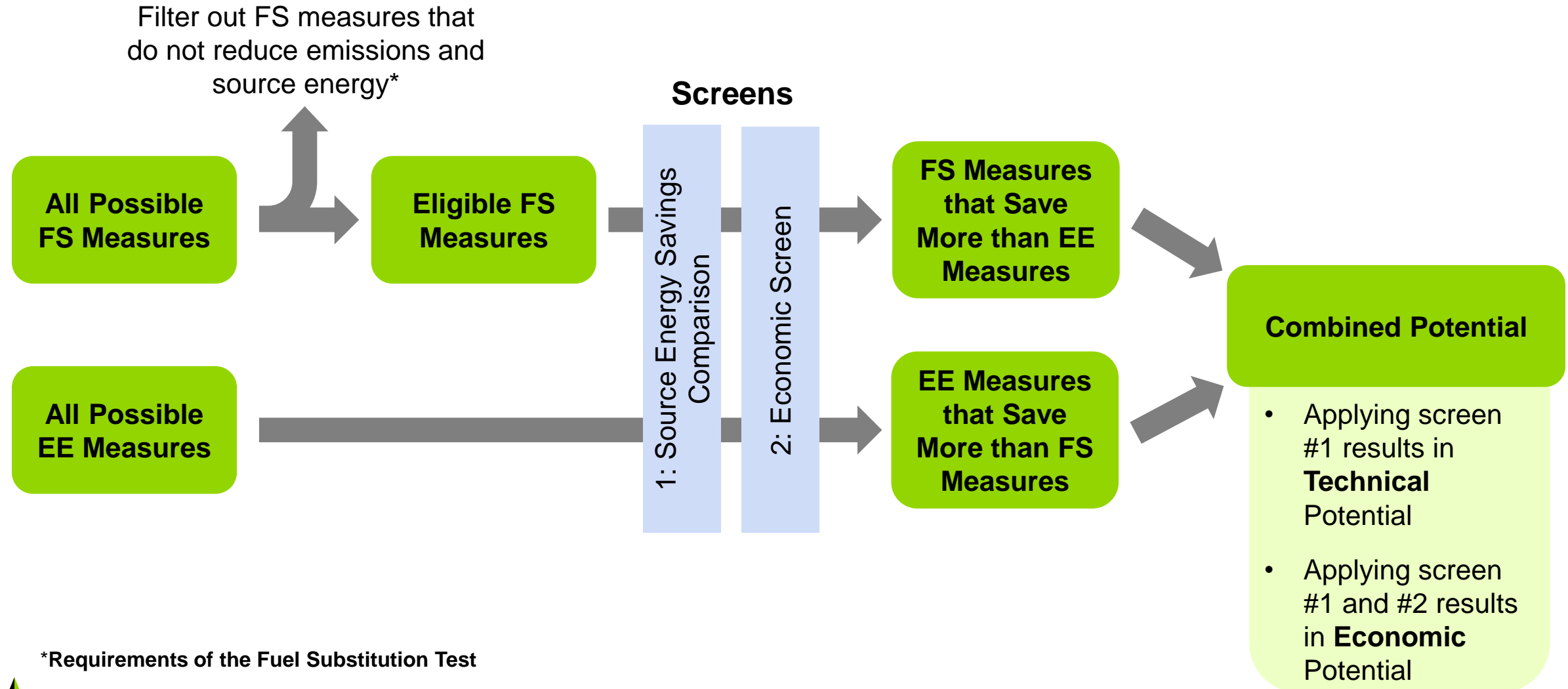
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Competing FS with EE Measures

- Traditional EE measures compete based on maximum <u>same fuel</u> savings

- FS measures decrease gas consumption and increase electricity consumption

- Common units are needed to account for consumption of fuels of each type

The FS technology saves more source energy, winning the competition and thus represents technical potential

Parameter	Baseline Gas Technology	Efficient Gas Technology	FS Technology
kWh Consumption	-	0	51.73
Therms Consumption	4.48	3.58	0
kWh Savings	-	0	-51.73
Therms Savings	-	0.90	4.48
Source Energy Consumption (Btu)	473	378	186
Source Energy Savings (Btu)	-	94	286

Illustrative

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Screening for Technical and Economic Potential

Filter out FS measures that do not reduce emissions and source energy*

Screens

All Possible FS Measures → **Eligible FS Measures**

All Possible EE Measures

1: Source Energy Savings Comparison

2: Economic Screen

FS Measures that Save More than EE Measures

EE Measures that Save More than FS Measures

Combined Potential

- Applying screen #1 results in **Technical** Potential

- Applying screen #1 and #2 results in **Economic** Potential

*Requirements of the Fuel Substitution Test

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Market Adoption of FS versus EE Measures

- Decision to adopt EE vs FS technologies are driven by very different consumer choice considerations

- Updates to adoption logic capture these differences and will be supported by the market study results

Illustrative Customer Preference Weightings by Technology Type		
Attributes	EE Measure	FS Measure
Lifetime Cost (LMC)	20%	0%
Upfront Cost	20%	30%
Hassle Factor	20%	40%
Eco Impacts	20%	5%
Eco Signaling	10%	5%
Non-conservation performance	10%	20%

Illustrative

Illustrative

FS 2
FS 1
Efficient 2
Efficient 1
Baseline
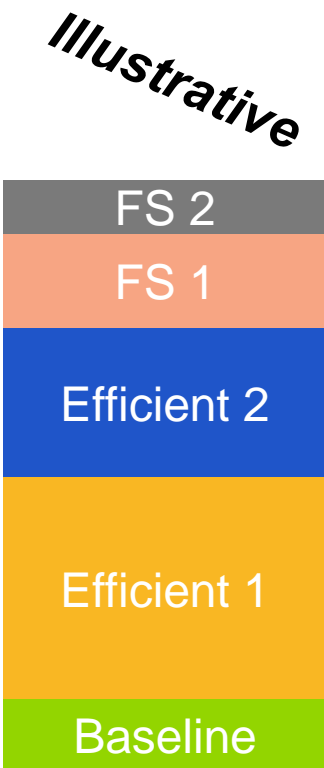
Questions

- Should FS potential be independent of the source of program funding?
  - Incentive layering: How should incentives from different sources be considered (e.g. there are different sources for incentives that cover measure cost and installation costs)?

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EE-DR Integration

Stakeholder Presentation
Julie Penning, Guidehouse
Brian Gerke, LBNL

Introduction

- **Discussion topics:**
  - EE/DR adoption logic
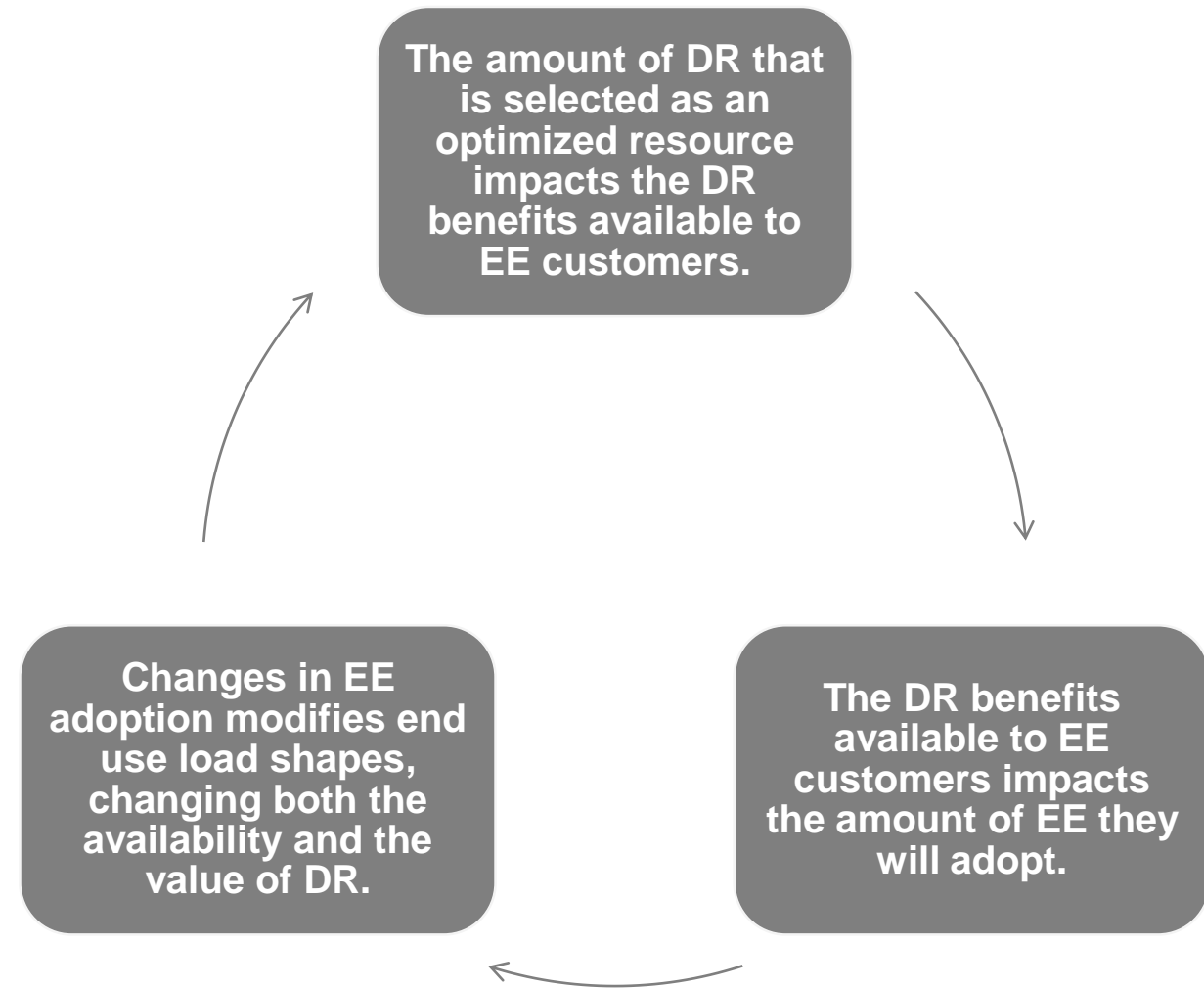 - DR Program Participation Logic (from the DR potential study)
- **Key questions for stakeholders:**
  - *What time horizon should be used for valuing DR technology benefits? (Technology lifetime or duration of program participation?)*
  - *Should customer awareness of DR programs be assumed to grow with time via marketing/word of mouth or is it relatively constant?*

> **Reminder:** EE and DR potential are being forecast in separate studies/models. Today's discussion is about simulating how EE and DR interact with each other to affect consumer decisions.

Background: EE and DR Integration

- Impetus to integrate EE and DR forecasting efforts:
  - Energy Efficiency business plan decision D.18-05-041

- LBNL developed most recent DR potential study

- Amount of EE adopted impacts amount of remaining DR potential

- To capture adoption of EE technologies in the EE market, use assumptions about availability of DR programs/incentives and co-benefits that impact consumer decisions

- EE and DR potential studies must be connected so they can best inform the integrated resource plan

The amount of DR that is selected as an optimized resource impacts the DR benefits available to EE customers.

The DR benefits available to EE customers impacts the amount of EE they will adopt.

Changes in EE adoption modifies end use load shapes, changing both the availability and the value of DR.

EE-DR Adoption Logic

EE-DR Modeling Approach

- Market Study will inform % breakdown of population into interest groups

- For both cost effectiveness and willingness:
  - Each interest group will witness different levels based on the benefits/costs they consider
  - A weighted average will be taken to obtain a single value for the given DR-enabled measure

Illustrative

DR

EE

EE + DR

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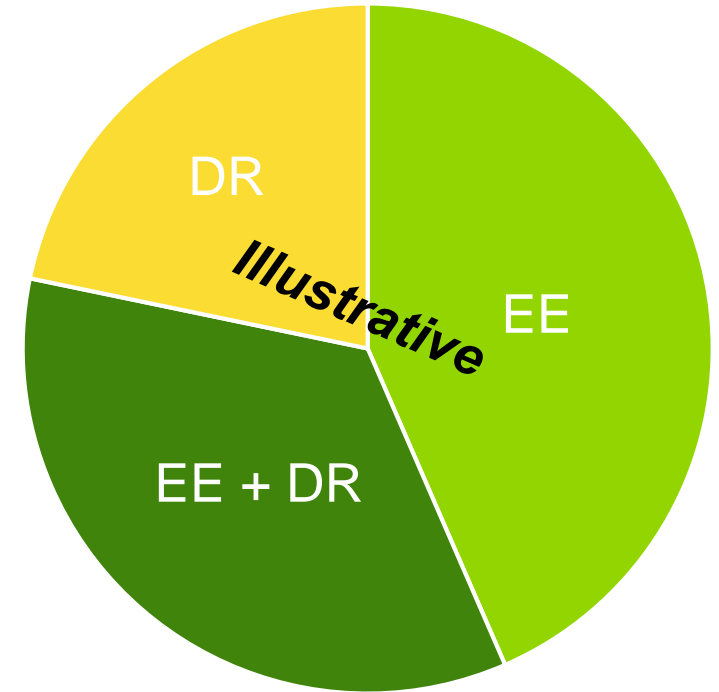
Output of model:
Adoption (units)

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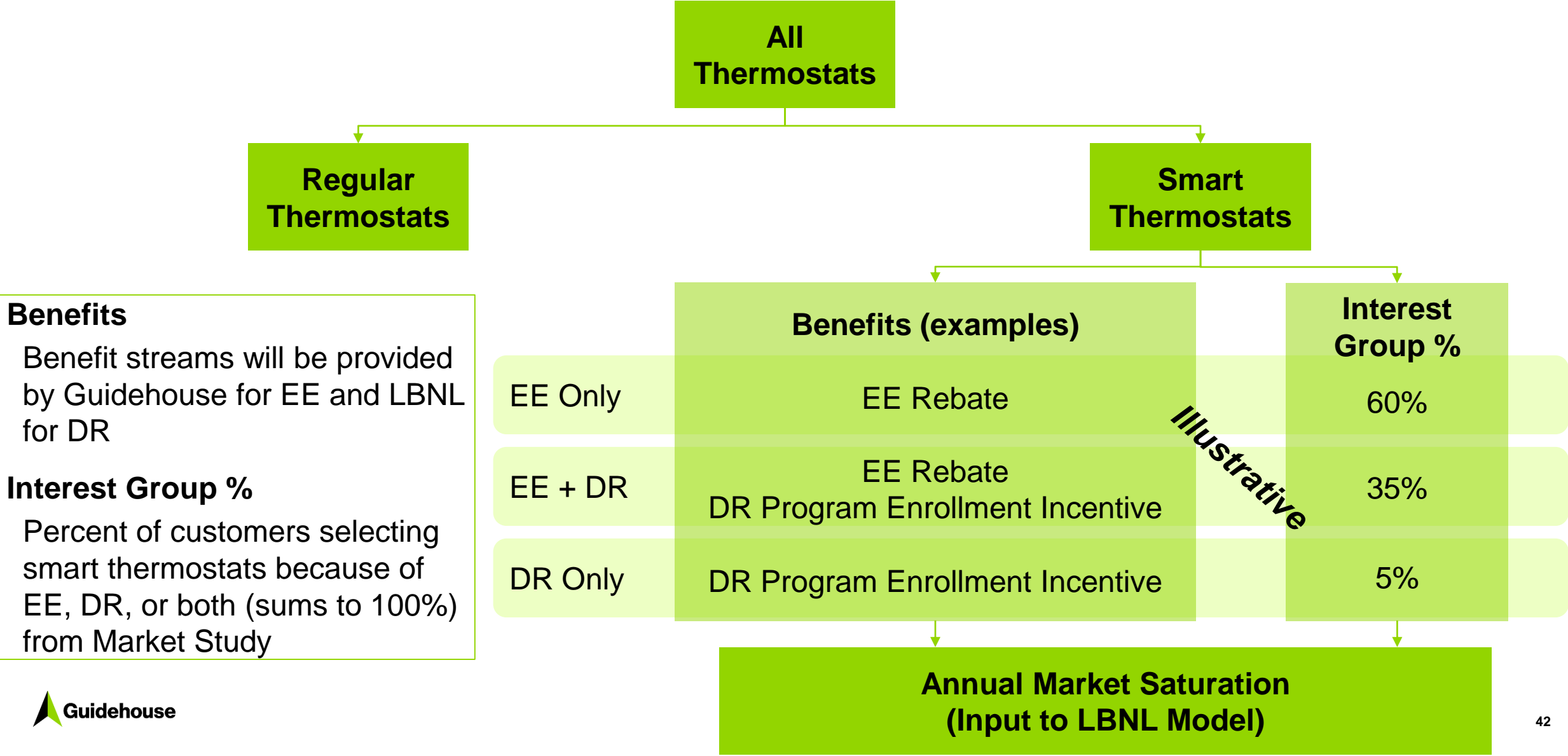Lawrence Berkeley National Laboratory

DR Program
Participation

Capturing Adoption Impacted by DR benefits

Attribute	Considers EE Only: Customer Preference Weighting	Considers EE+DR: Customer Preference Weighting
Lifetime Cost (LMC)	10%	10%
Upfront Cost	25%	25%
Hassle Factor	25%	35%
Eco Impacts	5%	5%
Eco Signaling	15%	10%
Non-conservation performance	20%	15%
Total	**100%**	**100%**

Illustrative

EE-DR Market Share: Illustrative Example

All
Thermostats

Regular
Thermostats

Smart
Thermostats

Benefits
Benefit streams will be provided by Guidehouse for EE and LBNL for DR

Interest Group %
Percent of customers selecting smart thermostats because of EE, DR, or both (sums to 100%) from Market Study

	Benefits (examples)	Interest Group %
EE Only	EE Rebate	60%
EE + DR	EE Rebate DR Program Enrollment Incentive	35%
DR Only	DR Program Enrollment Incentive	5%

Illustrative

**Annual Market Saturation
(Input to LBNL Model)**

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DR Program Participation Logic

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Modeling DR enrollment decisions

- To estimate the DR resource in the DR Potential Study, we model annual customer enrollment[*] in DR programs, given different levels of incentive.
- The model will use the annual market saturation values from the EE adoption model to compute the prevalence of EE measures that also enable DR.
- We will then compute customer enrollment probability using a consumer choice model that considers customer sensitivity to participation **incentives** and to **disruption** in energy service:

$$P_{enroll} = \frac{e^{c_I\ LIP\ +c_D\ DF}}{1 + e^{c_I\ LIP\ +c_D\ DF}}$$

Variables	LIP	**Levelized incentive payment** received for enrollment and participation in DR.
	DF	**Disruption factor**: the level of energy service disruption experienced by participating in DR. May vary by enabling technology and DR service.
Parameters	c_I	Customer sensitivity to incentive payments. May vary by customer segment.
	c_D	Customer sensitivity to energy service disruption. May vary by customer segment

*Since customers can typically enroll or unenroll from a DR program at will, enrollment probability is computed for all relevant customers in each year.
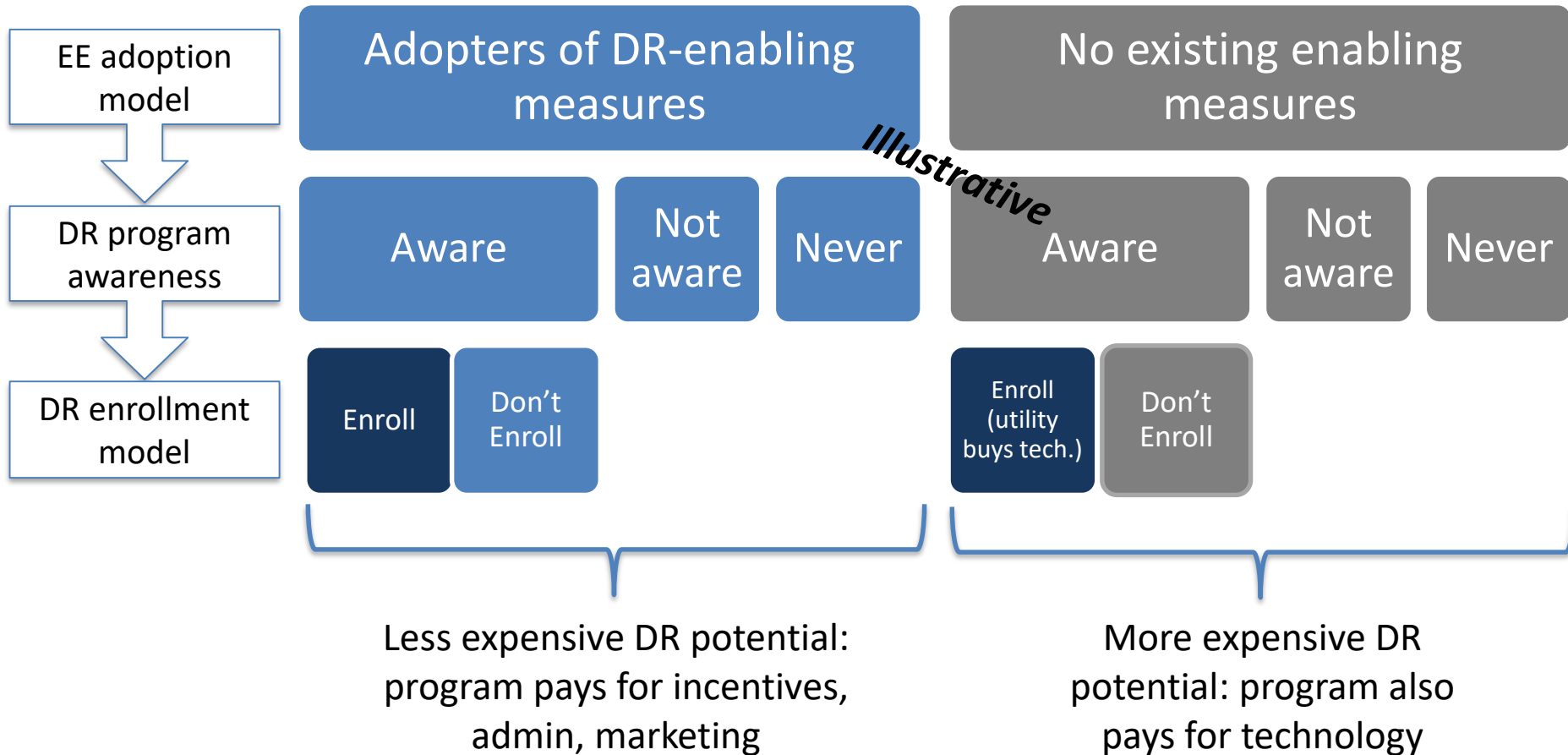
DR enrollment pathways

In each year, we can partition customers according to their **adopted DR-enabling measures** and their **awareness of DR.** Then we can compute DR enrollment for each customer group at varying incentive levels.
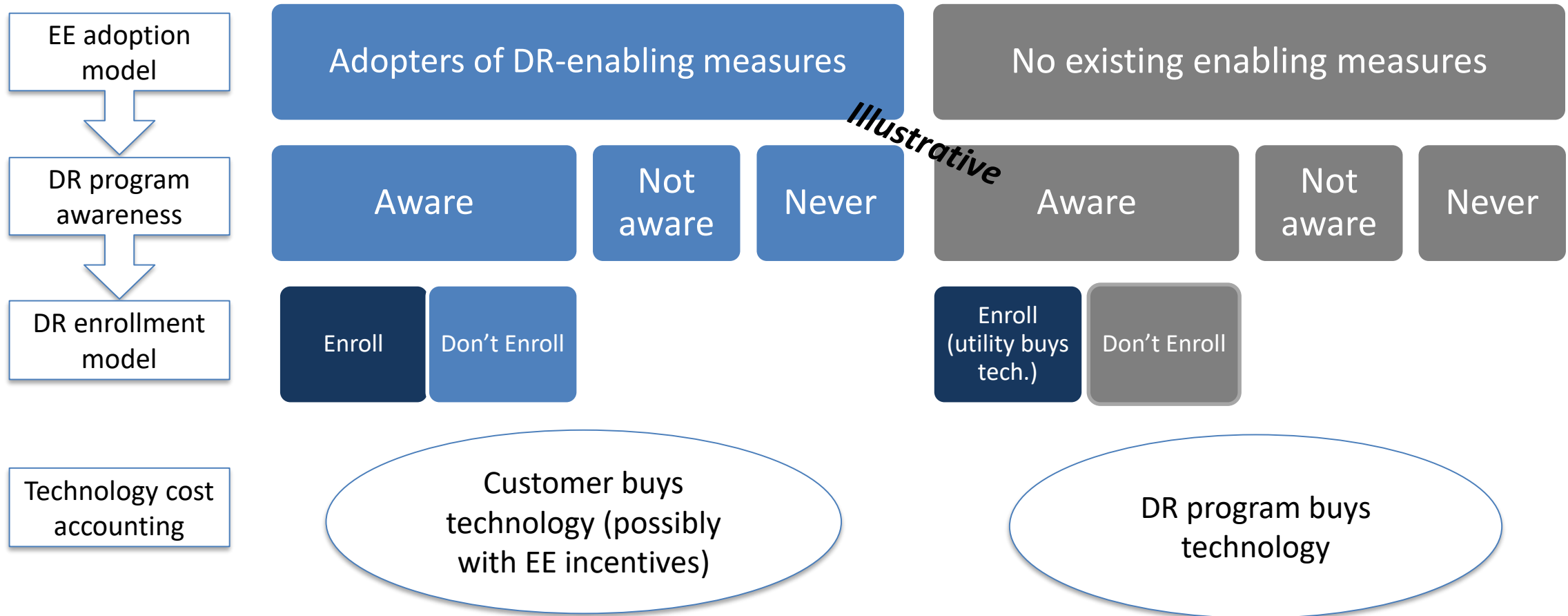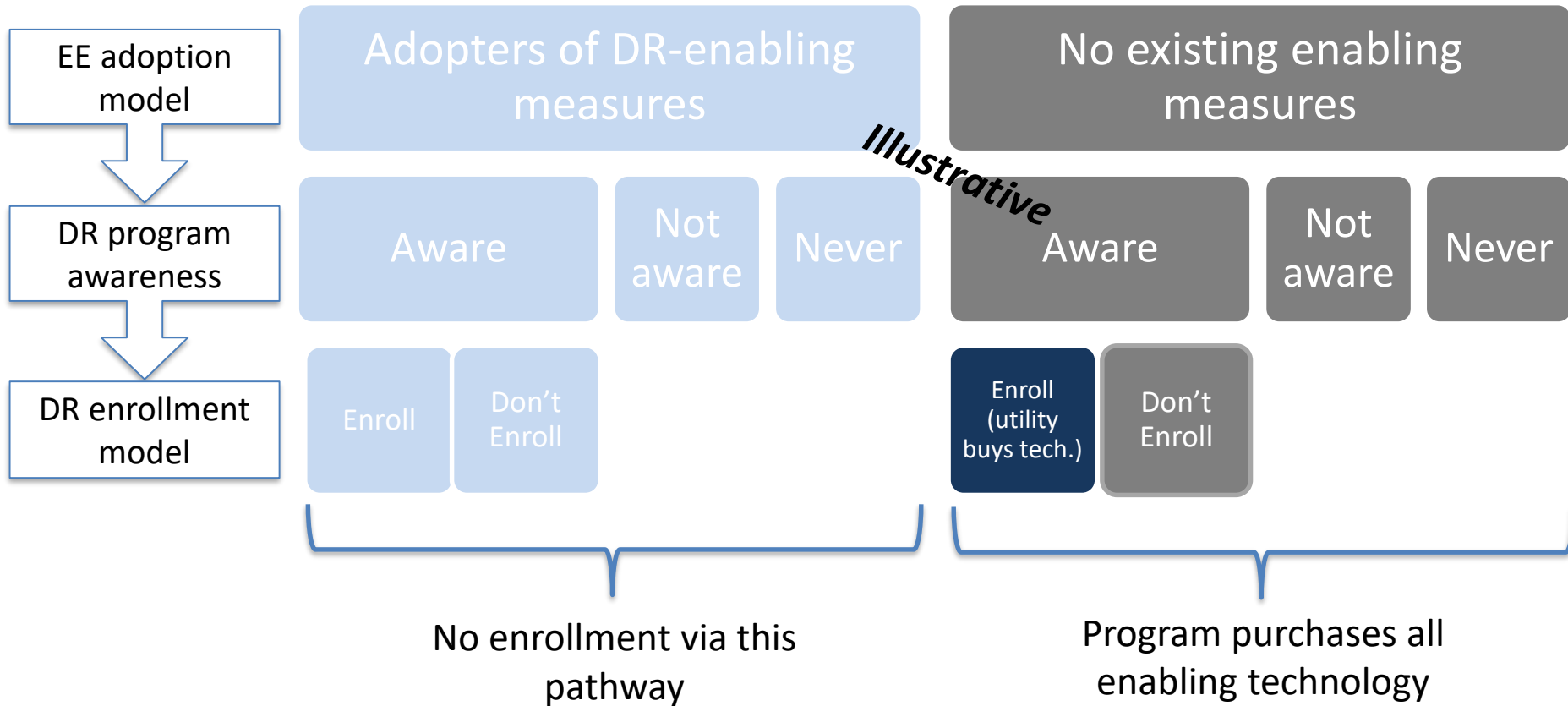
Example: Smart Thermostats

Current programs pay incentives to customers who have existing smart thermostats or purchase new ones. Additional DR potential may be available (at higher cost) if programs pay for the thermostats.

EE adoption model → DR program awareness → DR enrollment model

Adopters of DR-enabling measures
- Aware
  - Enroll
  - Don't Enroll
- Not aware
- Never

No existing enabling measures
- Aware
  - Enroll (utility buys tech.)
  - Don't Enroll
- Not aware
- Never

Illustrative

Less expensive DR potential: program pays for incentives, admin, marketing

More expensive DR potential: program also pays for technology

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Example: Direct Load Control

Customers are unlikely to pay for direct load control switches, since there are no customer co-benefits. All costs must be borne by the program.

Illustrative

EE adoption model → DR program awareness → DR enrollment model

Adopters of DR-enabling measures: Aware, Not aware, Never; Aware → Enroll, Don't Enroll

No existing enabling measures: Aware, Not aware, Never; Aware → Enroll (utility buys tech.), Don't Enroll

No enrollment via this pathway

Program purchases all enabling technology

Questions

- What time horizon should be used for valuing DR technology benefits? (Technology lifetime or duration of program participation?)

- Should customer awareness of DR programs be assumed to grow with time via marketing/word of mouth or is it relatively constant?

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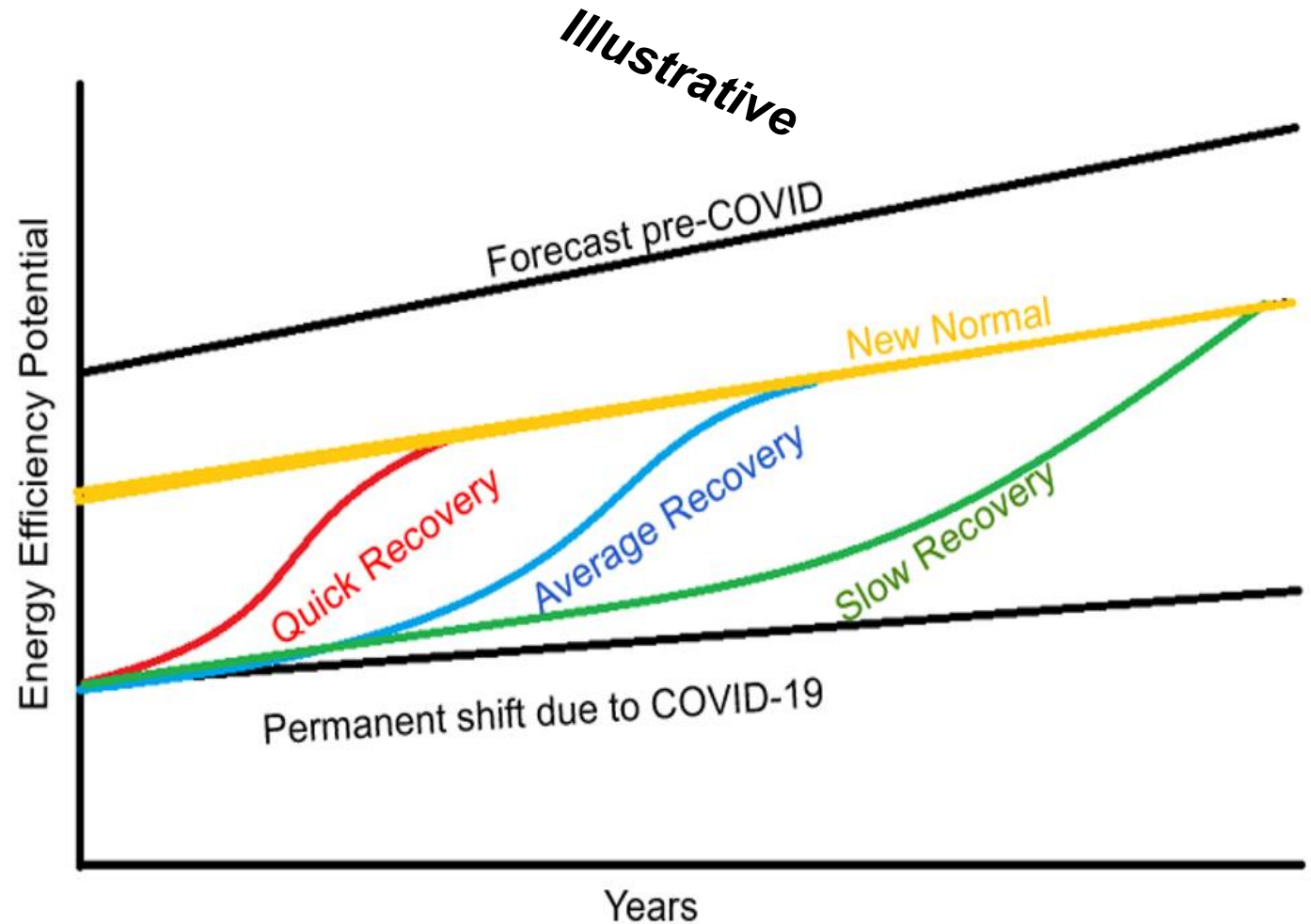# Addressing COVID-19 Impacts

Stakeholder Presentation
Amul Sathe, Guidehouse

Introduction

- **Discussion topics:**
  - Dealing with uncertainty
  - Measure characterization
  - Consumption and stock inputs
  - Adoption logic
  - Calibration

- **Key questions for stakeholders:**
  - How are current programs being impacted?
  - Does our proposed approach sense?
  - What economic recovery drivers should we look to?

Dealing with Uncertainty

- Energy consumption and peak demand loads are shifting

- Most spending and investment is down in almost all sectors

- Future economic recovery and consumption is uncertain

- Proposal is to bound the forecast, the actual forecast falls somewhere between these two bounds:
  - Permanent shift due to COVID-19
  - Pre-COVID-19 assumptions

Illustrative

Energy Efficiency Potential (y-axis) vs Years (x-axis)

Forecast pre-COVID
New Normal
Quick Recovery
Average Recovery
Slow Recovery
Permanent shift due to COVID-19

Key Takeaway: Data is limited; assumptions will be necessary

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Measure Characterization

Key Takeaway: No COVID-19 adjustments will be made at the measure level

Impact of COVID-19 at the measure level
- COVID-19 has impacted how much energy measures consume in the near term
- Possible adjustments to measure cost to be made given changing demand for measures

Reasoning for planned approach
- There currently isn't enough data to show how specific measures have been impacted to merit updating their characterization
- Updating measures for this study would deviate from DEER and CPUC approved workpapers which would introduce a misalignment with the PAs data source for their own program planning and analysis

Consumption and Stock Inputs

Key Takeaway: Coordinate with CEC on IEPR forecast derived values; make assumptions about recovery trajectory (or trajectories)

Impact of COVID-19 on the IEPR forecast level

– COVID-19 changed where energy is being consumed and how much of it is being consumed

– Building stock forecast may change; some building types may have high unoccupancy rates

– Recovery trajectories are unknown

Reasoning for planned approach

– The economy and shifts in energy consumption are volatile: neither show signs of predictable recovery rates as of now

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Adoption Logic

Key Takeaway: Market study contains questions attempting to bridge the gap between current and "normal" decision-making habits. Economic recovery trajectory will be used to interpolate between the two

Impact of COVID-19 on customer adoption

– Investment in nearly all non-essential goods has decreased

– Consumer choice patterns have changed its unknown if/when they will return to pre-pandemic patterns

Reasoning for planned approach

– Decision-making habits will change as the economy recovers

– Customers self-identifying their current vs. "normal" habits is our approach to set the bounds of their habits

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Calibration and Scenarios

Key Takeaway: Wait until Q1 of 2021 to select a recovery trajectory (or trajectories) and calibrate based on COVID-19 impacts

Impact of COVID-19 on calibration process
- Recent changes to consumer behavior complicate near term forecasting of adoption

Reasoning for planned approach
- There will be approximately a full year of data tracking the impact of COVID-19 by Q1 2021
- The economy and shifts in energy consumption are volatile: neither show signs of predictable recovery rates as of now

COVID- 19 Recovery Trajectories

|		R1	R2	R3
EE Policy Assumption Sets	P1	Scenario 1	Scenario 5	Scenario 9
	P2	Scenario 2	Scenario 6	Scenario 10
	P3	Scenario 3	Scenario 7	Scenario 11
	P4	Scenario 4	Scenario 8	Scenario 12

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Questions

- Are program administrators seeing a drop in overall program participation/savings thus far in 2020? How much?
  - Can PAs provide 2020 participation data in early 2021?

- Does our proposed approach to defer final decisions as late as possible make sense?

- What key drivers to economic recovery should we be monitoring?

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Next Steps

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Overall Schedule Reminder
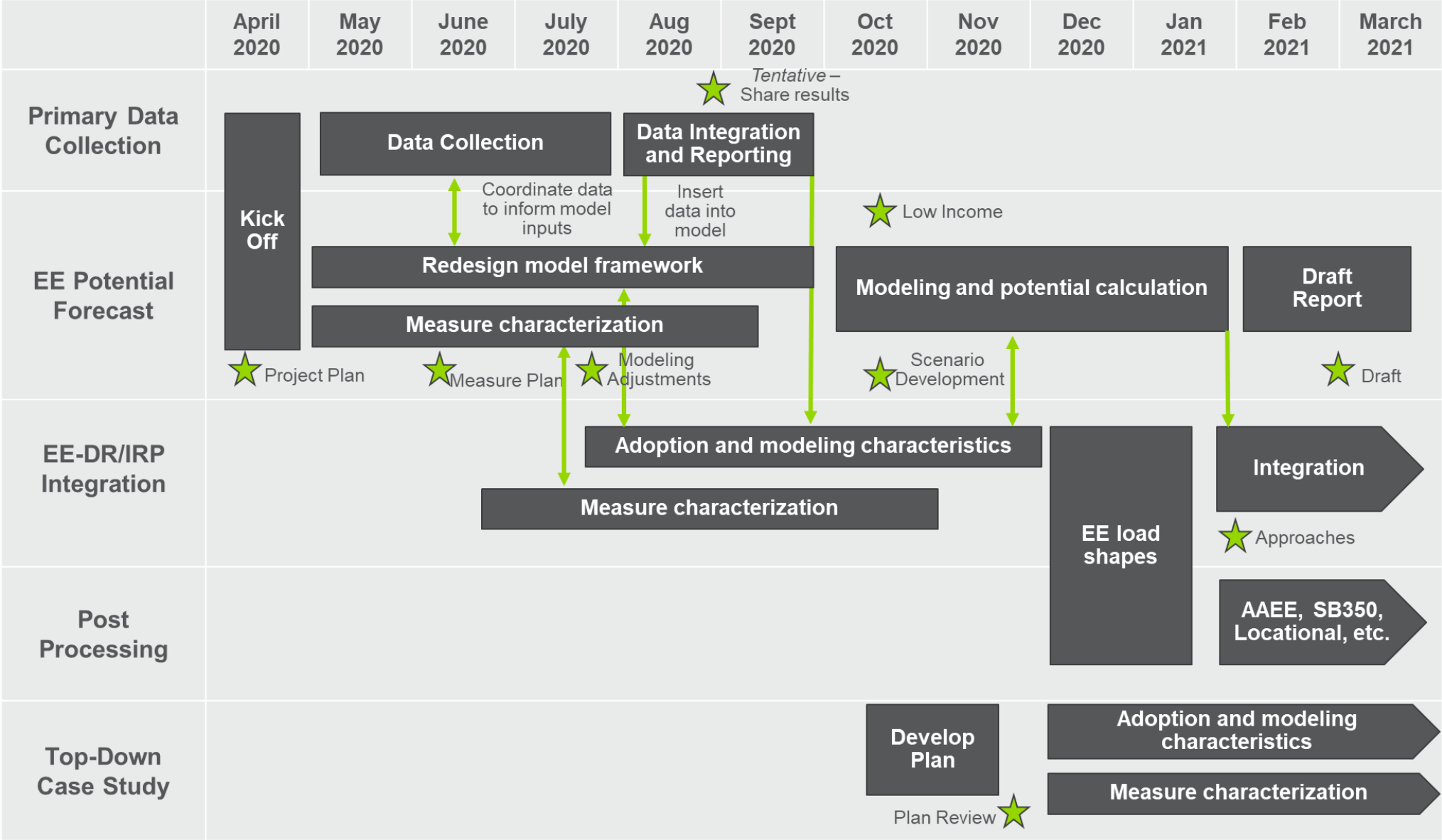
Reminders and Next Steps

Stakeholder engagement is critical and CPUC and the Potential and Goals Study team values the input and direction provided.

- Study-related comments are <u>informal.</u>

- Study-related comments on the topics covered today are due **August 4** via e-mail to:
  coby.Rudolph@cpuc.ca.gov & genesis.tang@cpuc.ca.gov.

We suggest comments be focused on the questions posed throughout this slide deck

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Stay Informed

CPUC's 2021 Energy Efficiency Potential & Goals Webpage:

https://www.cpuc.ca.gov/General.aspx?id=6442464362

CEC's Demand Analysis Working Group:

https://www.energy.ca.gov/programs-and-topics/topics/energy-assessment/demand-analysis-working-group-dawg

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